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Exploring trade-offs in climate change response in the context of Pacific Island fisheries

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ABSTRACT

Climate change poses significant and increasing risks for Pacific Island communities. Sea-level rise, coastal flooding, extreme and variable storm events, fish stock redistribution, coral bleaching, and declines in ecosystem health and productivity threaten the wellbeing, health, safety, and national sovereignty of Pacific Islanders, and small-scale fishers in particular. Fostering the response capacity of small-scale fishing communities will become increasingly important for the Pacific Islands. Challenging decisions and trade-offs emerge when choosing and mobilizing different responses to climate change. The trade-offs inherent in different responses can occur between various exposures, across spatial and temporal scales, among segments of society, various objectives, and evaluative criteria. Here we introduce a typology of potential trade-offs inherent in responses, elaborated through examples from the Pacific. We argue that failure to adequately engage with trade-offs across human responses to climate change can potentially result in unintended consequences or lead to adverse outcomes for human vulnerability to climate change. Conversely, proactively identifying and addressing these trade-offs in decision-making processes will be critical for planning hazard mitigation and preparing island nations, communities, and individuals to anticipate and adapt to change, not only for Pacific Islands, but for coastal communities around the world.

1. Introduction

Climate change poses severe – often existential – threats to coastal communities and ecosystems worldwide. Coasts are already experiencing adverse consequences, such as coastal inundation, erosion, ecosystem loss, salinization, increased vulnerability to extreme storm events, and transmission of infectious diseases [1–3]. Over the coming decades, risks related to climate change such as increasing climate variability, sea level rise, warming seas, ocean acidification, and deoxygenation are expected to increase [3]. An anticipated 50% of the global population will live within 100 km of the coast by 2030, further increasing human vulnerability to coastal storms, flooding, and other disturbances [3,4].

Socioeconomic impacts of climate change are unevenly distributed within and among nations, regions, communities, and individuals due to different exposures and vulnerabilities [5]. Globally, there is differential access to and distribution of resources, technology, information, wealth, risk perceptions, social capital, community structure, and institutions addressing climate change hazards, which is compounded by various exposure types, intensities, frequencies, and durations. Furthermore, climate change does not occur in isolation, but interacts with structural processes like poverty and marginalization. Ultimately, these interactions produce a suite of different social and ecological outcomes across temporal, spatial, jurisdictional, and institutional scales [5–7]. The goal of this exploratory paper is to recognize the nature of these different outcomes generated by climate change, and highlight subsequent trade-offs in climate change response, in the context of fishing communities of Pacific Island countries and territories (PICTs).

1.1. Climate change impacts on Pacific Island countries and territories

PICTs are extremely vulnerable to the impacts of climate change and in some cases face complete inundation, potentially requiring forced displacement [8]. Sea-level rise, flooding, and coastal storms are

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threatening the very existence of small atoll nations such as Kiribati and Tuvalu, by undermining food security, habitability, and human health and safety [9]. Leaders from these vulnerable atoll nations are already planning for relocation and reestablishment in new geographies, balancing the harsh reality of the stress that such actions will place on their people, while developing alternatives to ensure the continuation of cultural ways of life and sovereignty.

In addition to facing inundation from sea-level rise, many Pacific Island communities depend on their local, nearshore fisheries for food security, livelihoods, and cultural purposes [10,11]. In the context of climate change, fisheries in the tropics are currently threatened by major changes in fish distribution, with a predicted net movement of fish stocks out of the tropics into higher latitudes [12,13]. Coral reef degradation, from changes in water temperature and chemistry, is a major threat to essential fisheries habitat. Furthermore, an increase in intensity and variability in coastal storms can pose safety hazards to fishers and reduce access to fishing as an important livelihood source.

1.2. Climate change and human rights

The interactive effects of climate change with inequalities already experienced by PICTs and marginalized populations threaten fundamental human rights; climate change can erode small-scale fishing livelihoods and food security thereby threatening social, economic, and cultural rights. Forced migration and loss of sovereignty severely undermines civil and political rights [14]. Thus, actions must be taken to create and enact climate change policy to alleviate the effects felt by the most vulnerable.

While human rights are threatened by climate change, climate change policy can further exacerbate existing inequalities [15]. Climate change mitigation and adaptation policies can be at odds with development and poverty alleviation goals, generating trade-offs and unintended consequences [16,17]. For example, in the context of the PICTs, marine protected areas designed to buffer the effects of climate change on the local marine environment can preclude access of small-scale fishers to their livelihoods and food sources, making them more vulnerable to subsequent climate-related disasters [18,19]. On the other hand, failure to maintain resources through adequate management and conservation strategies can also result in significant social and economic impacts. Thus, there is an important need to evaluate ancillary costs and benefits of climate change policy against development goals, as well as distributional impacts on different demographics, populations, and communities [16].

1.3. Climate change response

Given the global scale of climate change, the variance in country-level contribution of green house gas emissions, and disproportionate impacts experienced locally and regionally, climate change mitigation usually occurs at the level of the national government in response to international negotiations, while adaptation generally occurs at the local level [20]. Collectively, the degree to which individuals, households, communities, societies or nations can respond to climate change is determined by available assets, the rights afforded to them, and their relative agency to access and leverage these assets and rights [21–23]. The resulting latent quality, response capacity – also defined as a broad pool of development related resources that can be mobilized in the face of risk, describes the ability to both *mitigate* climate change impacts and *adapt* to experienced or anticipated impacts [20]. Response capacity is linked to actual decisions and actions by socio-cultural factors like risk perception and access to information [24]. For example, high response capacity in a given household does not always engender immediate response in the face of climate change if perceived risk is low. These realized responses to climate change can be involuntary, passive, planned, autonomous, reactive (ex-post), or anticipatory (ex-ante) [20,25,26].

Depending on key decisions made during climate change response, alternative outcomes can emerge – putting nations, communities, or households on a pathway that is adaptive or maladaptive [27]. Such decisions may be contingent on addressing questions such as [28]: what climate phenomenon (or non-climate phenomenon) requires immediate response and at what temporal or spatial scale? Who or what is expected or mobilized to respond? How does response occur? For example, is it a reactive coping strategy mobilized by a fishing household after a big storm event? Or is it a fishing cooperative's anticipatory attempt to confront potential hardship by setting aside a disaster relief fund? Is it mangrove restoration by a community organization to improve storm buffers and fish nurseries? Or is it the allocation of development funds by the national government for community health clinics? The response landscape comprises alternative actions that might be considered, each with the potential for tradeoffs or synergies. In other words, the benefits and costs of responses can accrue differentially across scales, sectors, populations, systems, and so on. [23]. These trade-offs and synergies can be a result of explicit choice or completely unexpected and unanticipated dynamic interactions that emerge over time [29].

Remarkably, trade-offs are often overlooked in climate mitigation and adaptation planning and decision-making, as well as other conservation and development policies [30]. Trade-offs are inherently value-laden and thus power and politics play a critical role in the initial recognition of potential trade-offs, and in subsequent decisions to address certain trade-offs (or not). Some trade-offs may be invisible through a difference in values, or be hidden under dominant discourses [31]. Often the most vulnerable do not have a voice in decision-making, thus trade-offs relevant to them will not be brought to the table [30]. Another challenge precluding the explicit consideration of trade-offs are that innovative and novel solutions are likely required to adequately address them, requiring resources and time [31]. Despite these challenges, it will become increasingly critical to bring trade-offs to the forefront of climate policy discussion and decision-making; climate responses that ignore trade-offs can result in unintended consequences or mal-adaptations with severe consequences for the most vulnerable [27].

The central contribution of this paper is to explore the potential trade-offs inherent in mobilizing different responses to climate change, which might be used to encourage explicit attention to trade-offs in decision-making for avoiding maladaptive processes. Next we will propose a trade-off typology and discuss examples of these trade-offs in the context of fishing-dependent communities and households in PICTs.

2. Trade-off typology

Deliberate or dynamic trade-offs inherent in climate response may occur across and within various exposure types, among desired objectives, across and within scales, among segments of society, or in evaluative criteria (Fig. 1, Box 1). Furthermore, alternative actions and subsequent trade-offs in one domain can result in dynamic interactions across domains (Fig. 1). For example, a decision to prioritize economic objectives over socio-cultural objectives in climate change response can generate trade-offs across segments of society (Fig. 1). Thus trade-offs can be sequential or synchronous. Although path dependence among trade-offs may move systems along maladaptive pathways towards social-ecological traps, greater recognition of and preparation for trade-offs in climate change response, can increase the potential for reversing these traps [27]. The subsequent sections are not meant to be an exhaustive or systematic analysis of trade-offs, but rather an exploration of six potential trade-off domains and their relevance to fishing communities in PICTs.

2.1. Trade-offs among and within different exposures

Households, communities, and countries face myriad exposure

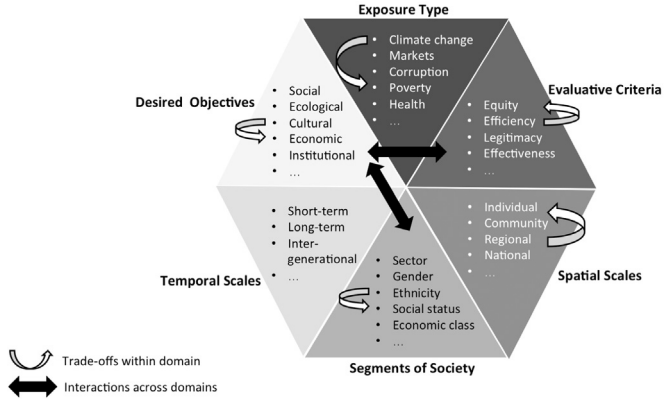


Fig. 1. Typology of potential domains of trade-offs: exposure types, desired objectives, temporal scales, spatial scales, segments of society, and evaluative criteria, demonstrating hypothetical examples of trade-offs within domains as well as interactions across domains. The six domains and associated attributes pictured here are meant to be exemplar not exhaustive.

types, both relevant to and outside of climate change. While sea level rise, increased storm events and intensities, loss of coral reefs, and declining fisheries may all be processes generated by climate change, they will likely require unique responses at different spatial, temporal jurisdictional, and institutional scales. In addition to climate-driven exposures, humans also face poverty, poor health, market change, corruption, demographic shifts, impacts from coastal development, conflict, social marginalization, and human rights violations. These various exposures rarely act in isolation, but may instead have combined and synergistic effects on people and the environment.

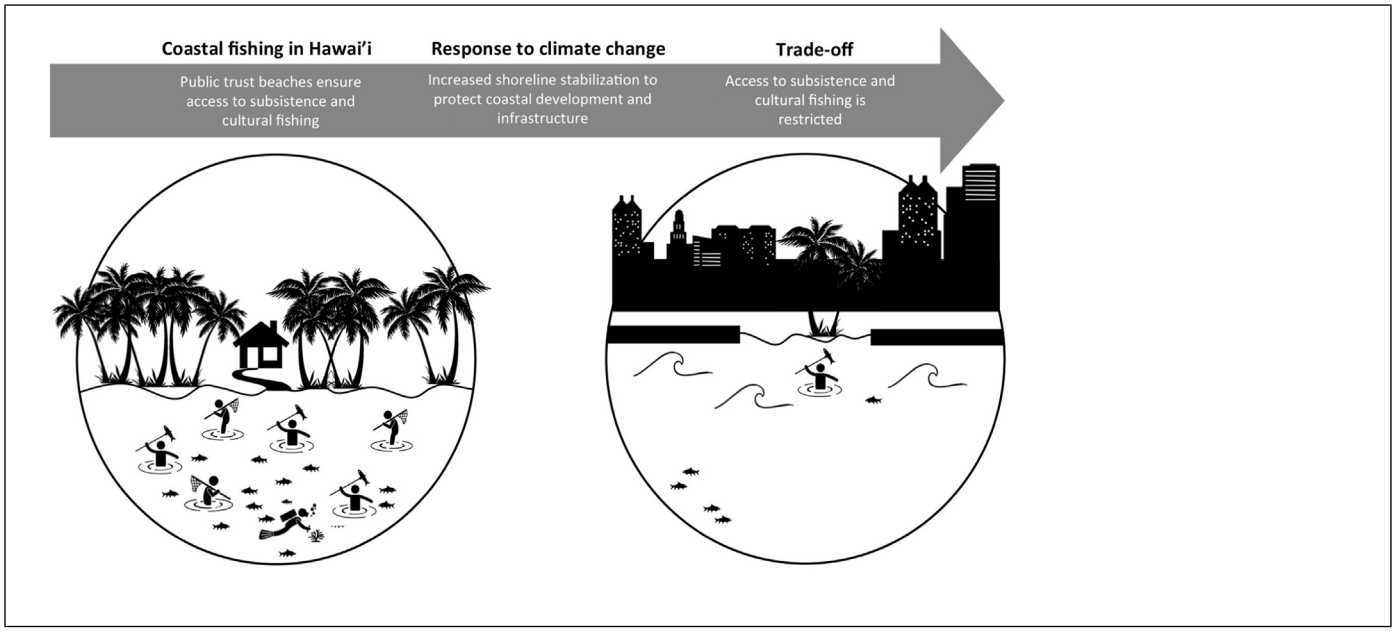
In such cases, individuals and institutions are faced with difficult decisions about which exposure to respond to, sometimes at the expense of increased vulnerabilities to other exposures [32]. For example, a concerted effort to relieve poverty and food insecurity might require increasing access to local fishing grounds. This in turn, may leave local communities dependent on fisheries for livelihoods and food security more vulnerable to shifting fish distributions from climate change [33]. Similarly, climate change and climate change response can engender perverse social, economic, or environmental outcomes undermining poverty alleviation and sustainable development [26]. For example, at the household level, capital asset mobilization in anticipation of a climate-driven shock reallocates assets previously available for economic productivity and stability [17]. The Republic of Marshall Islands (RMI) face sea-level rise, inundation, and forced migration – serious threats that interact with high rates of poverty, lack of access to health care, and a high dependence on foreign aid [9]. Thus, climate change must be considered in a wider context where other exposures are at play in determining vulnerability [26].

2.2. *Trade-offs among desired objectives and associated domains of response*

Depending on exposure types and other factors, responses can span conservation to development domains in order to achieve ecological, social, cultural, institutional, and economic objectives. For example, possible local responses to climate change could include stewardship of ecosystem function and diversity through sustainable use (ecological objective), maintaining diverse livelihood portfolios to increase economic alternatives outside of fishing (economic objective), fostering

Box 1

Hawai'i example of climate response-driven trade-offs. The Hawaiian public trust ensures Native Hawaiian gathering rights and access to coastal areas and beaches for cultural and subsistence purposes. Policies intended to address imminent beach erosion and inundation from sea-level rise [59], including hard stabilization of the shoreline to protect coastal development and infrastructure, can preclude access to coastal areas [60]. Loss of coastal access disproportionately affects the poorest communities in Hawai'i who rely the most on direct access to the coastal environment, including Native Hawaiians and ethnic Micronesian communities facing discrimination, high rates of homelessness, and lack of access to basic services [60]. This trade-off represents multiple dimensions of the typology (Fig. 1): **Exposure type** - here, climate change is interacting with coastal development and processes of discrimination and poverty; **Desired objectives** - economic objectives of protecting coastal infrastructure particularly for tourism may undermine objectives of protecting cultural and social services of the nearshore environment; **Segments of society** - this climate response may disproportionately affect ethnic minorities and communities with lower socio-economic status; **Spatial scale** - shoreline stabilization may be an ideal policy response to sea-level rise at a regional scale, but with trade-offs at the community, household, or individual scale; **Evaluative criteria** - here, effectiveness or efficiency in addressing sea-level rise comes at the expense of equity.



local memory and social learning processes for responding to change through strong civil society organizations (social and cultural objectives), and/or the presence of legitimate and inclusive local governance institutions for co-management or other participatory processes (institutional objective) [4].

However, because of differences in priorities and goals across these objectives and response domains, and the consequences of resource and funding allocation, trade-offs can emerge. A marine protected area or place-based exclusive fishing rights designed for ecological protection or sustainable use could exclude access for vulnerable or migrant fishers, undermining social well-being [34]. A focus on alternative livelihoods for economic diversification may have ramifications for local norms, culture, values and other social dimensions of fishing communities [35,36]. Although fisheries may vary across the Pacific in terms of economic contribution to local economies [37], their sociocultural importance regardless cannot be overstated [38–40]. Thus, achieving a singular objective might be desirable in some circumstances when resources need to be allocated to solve a critical issue, but attention must also be placed on potential cascading effects and trade-offs resulting down the line [27].

2.3. Trade-offs across and within scales

As climate change connects global scale processes to local, with both short-term and long-term intergenerational implications, the concept of cross-level and cross-scale interactions, including temporal, spatial, jurisdictional and institutional, is germane to this discussion [7]. Here we explore spatial and temporal scale trade-offs as examples.

2.3.1. Spatial scale

Climate change is a globally produced phenomenon, with wealthier countries contributing disproportionately more to the problem, and poorer countries and vulnerable populations feeling the brunt of the impact. A spatial scale mismatch occurs because most climate change policies are crafted at the national level, while most impacts are felt at local and regional levels [23]. For example, resources directed towards National Adaptation Plans of Action (from the UN Framework Convention on Climate Change, UNFCCC) might be diverting funding and attention from local level adaption efforts [17]. Furthermore, response capacities across individuals, households, communities, regions and nations are interconnected and not independent [41,42]. Cinner and Bodin [43] found that with increasing socio-economic development, adaptive capacity was compromised at the household level as livelihoods became increasingly specialized, but at the community level economies remained diversified and resilient.

2.3.2. Temporal scale

Addressing some climate related changes can require immediate responses involving hefty short-term costs to alleviate both experienced and anticipated future impacts. Thus, an important temporal mismatch occurs between the necessity of short-term costs and investments and the long-term and intergenerational effects of climate change [26]. Specific examples of climate change responses rooted in different philosophical origins generating temporal trade-offs include vulnerability and resilience [44]. A vulnerability-based approach to climate change response would focus resources and attention on communities or groups of people with past or present vulnerabilities. A resilience-based approach would focus on the intergenerational effects of climate change and long-term future of social-ecological systems. In Pacific Islands such as Hawai'i, maintaining customary access to resources – and the indigenous values systems that underpin them – could become important sources of community resilience over time [10,40]. Thus, there is a critical need to balance trade-offs between short- and long-term timescales; in doing so we can increase the likelihood of not just developing and strengthening coping capacity, but facilitating longer term adaptive and transformative capacity as well.

2.4. Trade-offs among different segments of society

Climate change response can lead to outcomes with important trade-offs across social status, economic class, race, ethnicity, gender, or other sectors of society, particularly for the most vulnerable and marginalized. Importantly, societal groups will have differential access to rights and capital assets with varying levels of agency, generating differences in response capacity. In particular, coping strategies or reactive responses can be associated with potential costs that are not distributed equally within communities or households [17]. Groups with higher response capacities, who take action in the face of climate change, may be doing so at the expense of another group. For example, the industrial fishing sector may have an unfair advantage over the small-scale fishing sector, given their capacity to follow fish over long distances as their distribution shifts with changing ocean temperature. Access to fishing gear, loans, credits, and emergency funds are not necessarily evenly distributed across fishing collectives or even within collectives, benefiting certain individuals with great socio-economic standing and political clout while further marginalizing other individuals during times of crisis [45]. In the Philippines, household-level assets may only be accessible and available for men, putting women at greater risk during a climate related event [46]. Likewise, in American Samoa, the establishment of strict no-take reserves in nearshore areas may have disproportionate effects on women who rely on reef gleaning for local food production [47]. Underestimating the importance of part-time fishing and gleaning activities in this context, particularly by women [48], may lead to inaccurate assessments or unequal distribution of benefits.

Careful attention must be paid when crafting climate change policy to prioritize the values and needs of the most marginalized and vulnerable groups. Furthermore, success of climate change policy should be evaluated not only by the degree to which the desired objective is achieved, but also by measuring the degree to which the policy helps or constrains others to reach their adaptation or mitigation objectives [41].

2.5. Trade-offs in evaluative criteria

Depending on exposure type, desired objectives, response domain, and scale, different evaluative criteria may be prioritized or achieved in climate change response. Legitimacy, equity, efficiency, and effectiveness are consistently identified as evaluative criteria [49] throughout the climate change literature [23]. Effectiveness is the degree to which a climate change response reaches its stated objectives; efficiency is the consideration and measurement of costs and benefits to balance short-term costs with long-term benefits; equity recognizes that climate change is inherently inequitable because of trade-offs across space and time, and prioritizes addressing existing inequalities and vulnerable populations; and legitimacy is closely linked to the underlying distribution of political power [41].

Obvious trade-offs exist for example, between the criteria of equity and efficiency, where efficiency may have to be compromised to ensure climate change and climate change response does not further exacerbate existing inequalities. A critical prioritization exists between equity and efficiency criteria from the viewpoint of the most vulnerable PICTs; maximizing efficiency in the *global mitigation* of climate change is perhaps the most important outcome to prioritize, particularly for low lying atolls in imminent danger of submersion [15]. Importantly, it has been suggested that balancing trade-offs among different evaluative criteria should be a deliberative process characterized by social consent and action [41].

3. Discussion

This proposed typology of trade-offs in response to climate change, elaborated through examples from the Pacific, can be used to encourage

greater attention to trade-offs in decision-making. It is important to point out that the proposed categories are not mutually exclusive, nor are they exhaustive; trade-offs can occur across and outside of the six domains articulated. Regardless, more explicit engagement with trade-offs in considering climate change responses can help to maintain coastal communities on an adaptive pathway and to avoid maladaptive responses and social-ecological traps [27].

An important commonality across domains is the difficulty in balancing social and ecological objectives. Given that climate change is inherently an inequitable phenomenon and its impacts are compounded through interactions with social structural processes and context, it has important ramifications for both social and ecological systems alike. Likewise, both mitigative and adaptive climate change policy may be at odds with poverty alleviation and development goals, generating further trade-offs across social and ecological domains. The situation is perhaps most dire for low-lying Pacific Islands where development goals and human rights considerations will need to be balanced with immediate climate change response. While for many communities migration is used as an adaptive response to climate change, forced migration due to inundation and a resulting loss of sovereignty is a serious threat to fundamental human rights [50].

After meaningful and deliberative consideration of a given climate change response landscape and the trade-offs inherent in a particular context, comprehensive responses can be crafted to generate positive synergies in lieu of trade-offs [51]. Examples of such comprehensive responses include approaches such as scenario-based stakeholder engagement [25], a participatory and inclusive process of incorporating stakeholder values when thinking through potential future scenarios of climate change. Autonomous adaptation emphasizes the integration of local knowledge into adaptation response, moving beyond technocratic and scientific responses tending to marginalize the most vulnerable [26]. Facilitative adaptation is an effort to foster local-scale autonomous adaptation through centralized efforts [20]. Trade-offs also highlight the importance of combining different adaptive tools and responses; for example, MPAs can be combined with livelihood diversifications, expansion of tenure rights, and seafood certification to simultaneously address ecological conditions, equitable access to resources, and improved market access [52]. Importantly, all of these approaches emphasize *local* and *anticipatory* response through the creation of enabling policy or conditions at the national and international scale [17]. Furthermore, knowledge co-production in recognition of and decision-making around trade-offs [31], and the integration of local lessons learned from past decisions made in the face of changing social and ecological conditions [53], can both help to facilitate and enable successful adaptation pathways in the face of current and future climate change impacts.

Comprehensive responses to climate change should also integrate social policy with climate policy. For example, in a no-regrets adaptation approach, the objective is to generate net social benefits under all future scenarios of climate change [17]. Similarly, 'sustainable adaptation' [26] and Adaptation, Mitigation, Sustainable Development (AMSD) [54] approaches emphasize "adaptation that contributes to socially and environmentally sustainable development pathways, including both social justice and environmental integrity" [26]. In sum, climate change responses intended to minimize trade-offs will integrate and prioritize development goals, focus on facilitating response capacity at the local scale through the creation of enabling conditions and policy at the national and international level, and as such, foster anticipatory (ex-ante) response.

Several important frameworks exist at the international level to help guide comprehensive climate response policies. In addition to the UNFCCC, the Sendai Framework for Disaster Risk Reduction [55] the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries [56], the Small Island Developing States Accelerated Modalities of Action (SAMOA) Pathway [57], and the UN Sustainable Development Goals (SDGs) [58] are all examples of integrative policy frameworks linking climate change and development goals. The Sendai Framework is a 15-year, voluntary, non-binding agreement which recognizes that the State has the primary role in disaster risk reduction but that responsibility should be shared with other stakeholders, with the stated objective of "the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries." The Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries are the result of a multi-year participatory, inclusive process, and are the first of their kind to emphasize using a human rights-based approach in securing sustainable small-scale fisheries. Section nine of the Guidelines, on 'Disaster risk and climate change', outlines important guidance for the creation of climate change policy in the context of fisheries with clearly integrated and articulated development objectives. The SAMOA Pathway represents a renewed commitment from Small Island Developing States (SIDS) and other countries to foster sustainable development and human wellbeing while combating climate change and protecting the environment. The UN SDGs represent a comprehensive set of goals to be achieved globally over the next 15 years, including ending poverty and hunger, stimulating climate action, and sustaining ocean life. These frameworks represent important progress on integrative policies for humans and the environment.

4. Conclusion

In summary, fishing communities in the Pacific Islands are critically vulnerable to the effects of climate change. Their livelihoods, food security, culture, safety, health, and sovereignty are all at risk. Furthermore, in a developing nation context, the effects of climate change interact with those of poverty and marginalization. Fostering the response capacity to climate change of Pacific Island nations and communities is therefore critical. This typology may be useful both for characterizing the trade-offs inherent in past responses, and for more careful recognition of trade-offs in future responses within and across various exposures, spatial, temporal, and other scales, segments of society, objectives, and evaluative criteria. Proactively identifying and addressing these trade-offs in decision-making processes will be critical for planning how to mitigate hazards and prepare island nations, communities, and individuals to anticipate and adapt to change, not only for Pacific Islands, but for coastal communities around the world.

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